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A SNOW-INHABITING ENCHYTRÆID (Mesenchytræus solifugus Emery) COLLECTED BY MR. HENRY G. BRYANT ON THE MALASPINA GLACIER, ALASKA.

BY J. PERCY MOORE.

The material upon which the present account is based was collected by Mr. Henry G. Bryant upon the snow of the Malaspina Glacier, while conducting explorations on Mt. St. Elias during the summer of 1897. The habitat of the worm is so unusual that a somewhat detailed account of its structure and habits seems desirable.

The mature examples, of which a considerable number were secured, are slender and linear, having about the form of *Fridericia longa.* They possess on an average 55 somites (43 to 58), and measure 15–20 mm. in length by .6–.7 mm. in greatest diameter (somite XII). At the oral end is a short, bluntly rounded and somewhat swollen prostomium. The oral somite is slightly enlarged and sharply marked off from the succeeding somite by a deep furrow. Somites II to V inclusive are somewhat depressed, the remainder of the worm being terete. In contracted specimens these anterior somites are distinctly divided into three annuli each. After increasing gradually to somite XII, the diameter remains quite uniform to about one millimeter from the posterior end, whence it narrows rather abruptly to the truncate anal ring.

In none of the specimens examined (about twenty in number) is the clitellum very distinctly developed, but on the contrary is thin and scarcely extends beyond the limits of the twelfth somite.

Dorsal pores are entirely absent from the somites, but there is a well-marked cephalic pore near the apex of the prostomium, fig. 7, *cp.* The external openings of the spermathecæ are situated in the centres of a pair of conspicuous elliptical swollen areas (figs. 1 and 2, *st.*), corresponding to the intersegmental furrow IV–V. These areas are much larger, more glandular, and more conspicuous than is usual in the Enchytræidæ. They lie toward the ventral rather than the dorsal body surface, and the spermathecal pores are between the levels of the ventral and dorsal setæ bundles.

Equally conspicuous in preserved worms are the often partially everted male genital bursæ, which appear as a pair of prominent papillæ (penes) on the ventral face of somite XII (figs. 1 and 2, ♂). At their apices are the male pores — triradiate slits with two short mesial limbs and a longer ectal one (fig. 1). When the bursæ are not everted, the male pores have the form of transverse slits on slightly elevated papillæ. The female pores (figs. 1 and 2, ♀) are very small, and are found only with some difficulty in entire worms. They are in line with the male pores and situated at the intersegmental furrow XII–XIII. The general characters of the anterior end of the worm are shown in figs. 1 and 2.

The setæ have the form usual in the genus, being feebly sigmoid and arranged in fan-shaped bundles, but are mostly imperfect, owing to the points being worn or broken off. The dorsal (lateral) bundles contain usually two, sometimes three, the ventral three to six in the preclitellial region, and usually four or five behind the clitellum. The ventral bundles are more conspicuous, not only because of the greater number of setæ which they contain, but also because these setæ are of somewhat larger size than the dorsal ones. Enlarged setæ are found in the ventral bundles of XI; these are about one-third longer and much thicker than the others. Setæ are absent from somite I, and the ventral bundles normally from XII. On the latter the ventral bundles are partially replaced by groups of pigmented glandular cells which lie ectad to the male pores. Sometimes a single small seta persists in this region. The dorsal bundles are sometimes also reduced on this somite and may be represented by two setæ, by one seta, by the pigmented glands or have disappeared altogether (as in one series of sections).

A very striking peculiarity of the species is the yellow-brown, deep chocolate-brown or almost black color, and its opacity. Mr. Bryant informs me that the worms were quite as conspicuously colored in life. Several of the specimens are marked by more or less complete white or yellow rings which are the result of ruptures of the epidermis along the intersegmental furrows, permitting the underlying muscular layer to show through. As Mr. Bryant states that these bands were present when the worms were collected, the injuries may be the result of previous freezing. Unstained sections show that the pigment is in the form of minute granules deposited thickly in the epidermal cells. These granules form a very densely packed stratum toward the outer surface of the cells, but become fewer and finally altogether absent toward their basal surface (fig. 8). Pigmentation is not confined to the outer surface of the body, but affects as well all internal epithelia which have been derived from ectodermal invaginations, as the setigerous glands, lining of buccal cavity and pharynx, genital bursæ, stalk of the spermathecæ, terminal vesicles of the nephridia and the lateral portions of the nerve cord.

Except that it is deeply cleft in front where its angles pass into the circumœsophageal connectives, the supra-œsophageal ganglion is nearly quadrate; the posterior border is almost straight. It is situated in somites I and II (fig. 4 and fig. 7, *cg.*). The body walls are unusually thin for an Enchytræid, which results from the weakness of the longitudinal musculature (fig. 8). The dorsal blood vessel becomes free from the alimentary canal in the clitellar somite (XII). It contains a usually inconspicuous cardiac body composed of two or three rows of cells.

No important peculiarities are apparent in the structure of the alimentary canal. The pharyngeal pad (fig. 2), occupies the second and third somites. It is preceded in the first somite by a pair of lateral appendages which project into the lumen of the buccal chamber. When retracted it forms the cephalic wall of a dorsal pouch, the posterior wall of which is the much-folded pharyngeal wall. Otherwise the alimentary canal is simply sacculated, and ciliated throughout. The chlorogogue cells begin in IV. They are very high and slender, the bodies very transparent, but filled with pigment (?) granules and fat like globules. Large septal glands are attached to the posterior faces of septa IV–V, V–VI and VI–VII, and occupy the greater part of the succeeding somites. There are no salivary glands (peptonephridia of Benham).

Nephridia are situated in every somite posterior to VII. These organs each consists of a long, narrow tube, very closely and intricately folded; but the loops do not communicate laterally with one another to form a plexus. Throughout its course the lumen is relatively large and the walls thin, so that the character of a tube is not obscured, as in many Enchytræidæ. The folded tube forms a compact mass divided into several lobes, of which a long, narrow ventral one, from the middle of which the efferent duct arises, and a short, broad, dorsal one are the principal. The part of the organ just described is postseptal. Only the small funnel and its stalk project through the septum into the somite next anterior.

The testes (fig. 3, *t.*), are attached to the body floor close to the root of the septum X–XI, and rather near to the middle line. Their products are shed while in early developmental stages into the cavity of somite XI, from which some find their way into X, but most pass into the sperm sacs to complete their development. The sperm sacs (fig. 3, *ss.* and *rss.*), are paired, but only the left one has any functional importance. Both arise from the septum XII–XIII, rather high up beside the intestine. Both are simple hollow tubular outgrowths whose walls have the same structure as the septa, being formed of a double layer of the very delicate cœlomic endothelium, with a very delicate and imperfectly developed muscular stratum between. That of the right side (*rss.*) is almost rudimentary, being narrow and confined to somite XII, in which it ends blindly, or possibly unites with the left after passing around to the ventral side of the intestine. Owing to the delicacy of its walls and the crowding of other organs, this point could not be certainly determined in the three series of sections studied. All appearances are, however, in favor of the interpretation expressed in fig. 3. The left sperm sac is greatly developed. Extending caudad from its origin through somite XII it passes to the ventral side of the intestine, and then occupying more or less approximately the middle line and perforating the successive septa, it continues into somite XX, in the posterior part of which it terminates blindly. At each septum it is constricted, but bellies out in the somites, and when filled with developing spermatogonia is the most conspicuous body in a section, not excepting the alimentary canal. Comparing it with the size of the testes it is a matter for wonder how the latter can produce sufficient spermatogonia to keep the former packed as full as they are usually found. The spermatogonia must divide many times.

The sperm funnels (fig. 3, *sf.*), have the large size, glandular appearance and narrow lumen so usual in the Enchytræidæ, and occupy most of the space by the side of the intestine in somite XI, the posterior septum of which is crowded backward.

Of a somewhat truncate pyriform shape, they are bent on themselves in such a manner that their mouths are directed toward the openings of the sperm sacs, while their stalks perforate the septum ventrad to the latter and pass into the sperm ducts. The sperm ducts (fig. 3, *sd.*) are remarkably long—about fifteen times as long as the sperm funnels—and form a pair of much coiled and twisted loops reaching in a typical example into somite XVIII. That of the right side enters the ovisac by its mouth and remains coiled within it by the side of the aggregated ova for the remainder of its course. In fig. 3 it is represented, for the sake of simplicity, as a straight loop The left sperm duct lies free in the body cavity, passing through the septa by the side of the left sperm sac, ventrad to which most of its coils lie. The sperm ducts are composed of a cubical epithelium and are ciliated throughout. Before entering the atrium in somite XII the recurrent limbs of the sperm ducts expand into narrow fusiform sacs (fig. 3, *ss.*), having glandular, epithelial and muscular walls, which receive the ductules of a group of unicellular spermiducal glands. This structure probably serves to form and eject the spermatophores. A narrow curved duct, which is also provided with some unicellular glands, perforates the mesial wall of the atrium and opens into its lumen.

Unlike the remainder of the male efferent apparatus, the atrium (fig. 3, *a*), is, in part, of ectodermal origin, as is indicated by the pigmented lining epithelium. It is a spheroidal thick-walled partly eversible sac, with an internal cavity having a mushroomlike shape in the retracted organ. Its walls are composed of a cuticle-covered, rather deep, pigmented and perhaps glandular epithelium, surrounded by a thick muscular layer in which the fibres are partly longitudinal, but largely radial, especially about the place of entrance of the sperm duct. A number of groups of unicellular glands are attached to the organ, and probably empty into its lumen. The external opening is described above.

The ovaries (fig. 3, *ov.*), arise from the floor of the body-cavity at the foot of the septum XI–XII. The ovipores have the usual Enchytræid form and relation. Their position is noted above. A single ovisac (fig. 3, *ovs.*), is present. This is pushed back from the septum XII–XIII, just dorsad to the sperm sac, which behind this point displaces it to the right for the greater part of its length. The sac is long and cylindrical, much constricted at the septa and is occupied, in addition to the ova, by one of the sperm ducts. In those specimens in which it is best developed it ends in somite XXII, but in some specimens it is less developed, and doubtless varies as in other species of *Mesenchytræus.* Sometimes ova are present in the posterior part only, in which case the anterior part, occupied by the sperm duct, is difficult to distinguish.

The paired spermathecæ (fig. 5) open externally between IV and V, and on a level midway between the dorsal and ventral setæ bundles. The epidermis about the opening is thickened in an elliptical area, owing to the presence of numerous unicellular glands. The stalk has a narrow lumen and thick walls made up as follows: (1) A thick lining cuticle; (2) a very deep epithelium consisting of a layer of cells divided into an inner (lumenal), which is unstained, and an outer (basal), stained and nucleated zone; at the plane of separation is a ring of pigment granules; (3) a very regular layer of longitudinal muscle fibres, one deep; (4) a layer of enlarged peritoneal cells, largest posteriorly and dorsally, and much smaller on the side toward the septum. The stalk passes mesiad along the septum, then turns dorsad and caudad, the muscular and peritoneal glandular layers cease, and the walls become thinner as the organ expands into the ampulla, which is sometimes very spacious, sometimes, as in the specimen figured, quite contracted. At the point where the stalk expands into the ampulla arise three slender, thin-walled diverticula, usually two from the outer and one from the inner (mesial) face. They vary in length, the longest about equalling the stalk. The ampullæ of the two sides open into one another, and the common sac thus formed by a small pore into the œsophagus on its dorsal side.[1] The epithelium of the ampullæ is of a character intermediate between that of the stalk and the diverticula.

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[1] I find upon reëxamining the material that several of the more slender and lighter-colored worms which I had taken for immature individuals possess spermathecæ of quite a different form. They are much smaller than those of *M. solifugus* and lack the diverticula entirely; they are simple club-shaped sacs, without specially enlarged ampullæ, and communicate neither with one another nor with the œsophagus. The epidermis about the spermathecal openings is not thickened. The male genital organs also differ; the saccus ejaculatorius is smaller, the walls of the atria less thick, and the external pore much less conspicuous. The posterior border of the supra-œsophageal ganglion is concave. These characters are exhibited by three specimens. The poor state of preservation of the specimens permits no further description. For this species the name *Mesenchytræus nivus*, which has not yet been published for the other, is proposed.

As established by Eisen ('78) as a subgenus, *Mesenchytræus* included Enchytræidæ having sigmoid setæ, a relatively short sperm duct, and a supra-œsophageal ganglion which, while truncate (straight or slightly convex) on the caudal margin, is deeply cleft cephalad; besides these characters certain peculiarities of the spermatozoa were mentioned. Michaelsen's studies ('88[a]) on *M. setosus* and other species have led him to add two very important and, among the Enchytræidæ, unique characters, viz., the presence of septal sperm sacs and ovisacs, and of lobate nephridia, in which the closely folded tubule can be traced as such. All described species of *Mesenchytræus*, which, following the usage of Michaelsen, is now ranked as a full genus, agree also in the possession of the following characters, in respect to which the genera of Enchytræidæ differ among themselves. The setæ are sigmoid and are asymmetrically arranged in the bundles, of which the ventral contain (at least anteriorly) a greater number of setæ than the dorsal. Dorsal pores are absent, but a large head-pore is situated near the apex of the prostomium. The dorsal blood vessel arises within[2] or caudad to the clitellum and contains a cellular heart-body. The blood is colorless. Salivary glands are absent. The supra-œsophageal ganglion is broader than long, deeply cleft anteriorly and straight or slightly convex posteriorly. The nephridia have very small anteseptal portions consisting of the funnel only, and large irregular massive postseptal portions. The sperm-duct is not more than ten times (Michaelsen says eight times) as long as the funnel. This statement of characters is derived mainly from Michaelsen's *Synopsis* ('89).

The "snow-worm" described above, presents all of these characters with the exception of the relatively short sperm ducts, which are about fifteen times as long as the funnels. The slight modification of the generic definition made necessary to receive this species is, however, unimportant, in view of the considerable variability in the length of this organ exhibited by species already known. In *M. fenestratus* Eisen ('78), the ducts but just equal the funnel in length, in *M. falciformis* Eisen they are six times and in *M.*

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[2] In an undescribed species from the neighborhood of Philadelphia.

beaumeri Michaelsen ('87) eight times as long. According to Eisen the relative lengths of ducts and funnels vary greatly within the limits of the single species *M. mirabilis* Eisen ('79), in some individuals the former being but four times, in others as much as ten times as long as the latter.

M. solifugus is, however, a very distinct species, whose nearest ally seems to be *M. mirabilis* Eisen. According to Michaelsen ('87), the latter species has a single sperm and a single ovisac, both of which are greatly elongated caudad and constricted at the septa. It further approaches *solifugus* in the elongation of the sperm ducts. The entrance of a sperm duct into the ovisac has not been described for any other member of the genus, in which these ducts are usually coiled up within the limits of somite XII. But the relation of the sperm ducts, and particularly of the right one, to the mouth of the ovisac, is such as to permit of ready entrance, and it may in future be found to take this position in some other species. The enlargement of the outer end of the sperm duct and its glandular appendages are better developed in this than in other species.

With but very few exceptions, the Enchytræidæ are translucent and colorless, or have but very little integumental pigmentation. Very remarkable and distinctive therefore is the thick opaque deposit of pigment granules in the epidermis of this species, and the conditions under which the worm lives make an explanation all the more difficult to find.

The foregoing description and much that follows were written and the accompanying drawings prepared in December, 1897. The paper was then laid aside pending some projected experiments designed to determine the physical factors effective in stimulating the production of pigments in the Oligochæta. No opportunity for carrying out this plan has been found, and in the meantime Prof. Emery has described the worm in two short papers ('98^a and '98^b) under the name *Melanenchytræus solifugus* from specimens collected on the Malaspina Glacier by Dr. Filippi, of Prince Luigi's party. The description is communicated at the present time at the request of Mr. Bryant. I had called the worm *Mesenchytræus nivus*, a name which is now discarded, owing to the earlier publication of Emery.

To the new genus *Melanenchytræus* the following characters are attributed by the describer: Epidermis pigmented; each segment except the first bears a dorsal and ventral bundle of setæ; the ventral bundle is lacking on somite XII, its position corresponding to the male pore; the sperm ducts form convoluted loops which extend into somite XV, and terminate in fusiform enlargements which receive the prostate glands and open into the bursæ; the spermatic sacs are large and extend through several segments; the spermathecæ do not communicate with the intestine, but are continuous the one with the other, and have each at the base of the ampulla two or three diverticula; the nephridia are much convoluted, with few nuclei; the dorsal vessel begins in XII, and contains a cardiac gland; there is a cephalic pore, but no dorsal pores; in the pharyngeal epidermis are found numerous branching pigment cells; there are no salivary glands and the œsophagus is continuous without special modification into the intestine; the cœlom of somites IV to VIII is for the most part filled with unicellular glands.

Nearly all of these characters, as has been pointed out above, are common to all species of *Mesenchytræus;* only the following of those mentioned by Emery are at all peculiar, viz., the pigmented epidermis, spermatheca without openings into the œsophagus, the elongated sperm ducts and the origin of the dorsal vessel in the clitellar somite. The first, although very remarkable, can hardly be given generic value. The second is an error, as the spermatheca do communicate with the œsophagus by a small pore; nor is the union of the two spermathecæ unique, as I find this character in a Philadelphia species which is strictly Mesenchytræid in every other respect. The unimportance of the relative lengths of the sperm duct and funnel has already been commented upon. The extension of the ducts posteriorly beyond the limits of somite XII is more important, but a similar course of the sperm ducts is described by Eisen for *Enchytræus* (*Neoenchytræus*) *vejdovskyi,* while in other members of this genus the ducts are closely coiled within somite XII. Michaelsen lays considerable stress on the origin of the dorsal blood vessel anterior or posterior to the clitellum, but the character cannot of itself be of much importance, owing to its variability. Thus in *M. beaumeri* Mich. the dorsal vessel arises in XVIII, in *M. flavidus* Mich. in XIII, and in an undetermined American species in XII. It seems to me, therefore, that the creation of the new genus *Melan-*

enchytrœus for *M. solifugus* is unnecessary, and the species is here referred to *Mesenchytrœus.*

The following account of the habits and environment of the snow-worms is due to Mr. Bryant:

" The snow-worms were first observed a few hundred yards from our first camp, on the edge of the snow mantle of the glacier, which at this time (June 17) extended to within a few miles of the terminal face of the glacier. By the first of August this snow mantle, which in places was six or seven feet in depth, had entirely disappeared, exposing the hard, compact ice of the glacier. The elevation of the first snow-camp referred to was 520 feet above sea level. Here but few specimens of the worms were noted. At our second camp on the snow (elevation 1,260 feet), they were quite abundant in places, as also at our next camp (elevation 1,580 feet), where their presence in large numbers irregularly dispersed presented the appearance of blotches of coarse dust on the snow. Our base camp was on a small expanse of snow-free ground on the south slope of a range of foothills abutting on the main range at an altitude of 1,750 feet. A few worms were observed on the adjacent snow of the main glacier, at a somewhat lower elevation; but I do not recall seeing any representatives of this species on any of our excursions in the upper snow fields of the region.

" During the month of June and early part of July, while the snow is comparatively dry, they appear about four o'clock in the afternoon on the surface and move sluggishly about, their dark color being quite conspicuous against the white background. They remain on the surface during the night; but when the sun appears in the morning they again burrow into the snow. They were widely distributed over the entire snow-field of the glacier, diminishing in numbers toward the edges. There was no uniformity in their dispersion. We did most of our sledging at night, and frequently passed stretches of snow several hundred yards in extent without noticing any specimens, and then would come to irregularly defined areas which seemed to support colonies of them, where the snow showed shadowy, dustlike patches caused by their presence in considerable numbers. As showing their sensitiveness to heat, I frequently observed their active wriggling as soon as a piece of snow containing them was taken in the hand. Later in the season, when the melting is further advanced and the snow saturated with moisture, the worms appear to become more active, and can be observed moving about in the shallow pools and lakelets which form on the surface of the glacier.

"When the snow entirely disappeared and the hard ice surface of the glacier appeared, the snow-worms were observed in the water which formed in the narrow crevasses. In my notes of August 2, I find the following: 'Collected some black worms to-day in a crack of the glacier—found them in the water of a high, narrow crevasse. Observed them on the edge of the submerged snow at a depth of five feet below the surface. The worms seem to have a browner color than when found on the snow earlier in the season. Some of the specimens I obtained had also distinct whitish bands around their bodies.'

"This variation in color is noticeable in the specimens collected in spring and late summer. As may be supposed, there is a marked absence of animal life on the surface of the glacier, which has an estimated length of seventy miles and a width of twenty-five or thirty miles. Wild geese were found nesting on the terminal moraine near the coast in June. The desolate monotony of the snow horizon was broken only on two or three occasions by the appearance of two species of Arctic gulls. Six species of moths, four species of spiders (one new species), and a number of flies, which included two or three new species, were collected on the glacier. The only insect found associated with the snow-worms was a minute black Thysanurian, which resembled at first glance a flea. This has been determined by Dr. Henry Skinner as *Achorutes nivicola.* These insects were found continuously and constantly associated with the worms in the dry snow, and, later on, in the pools of water. They were very active and leaped about like fleas. In no instance were lichens observed associated with the worms, although at several localities on the glacier pale crimson spots on the snow indicated the presence of the minute cryptogamic plants (*Protococcus nivalis*) which give rise to the 'red snow' frequently observed by Arctic travellers. The mean temperature of day and night on the expedition has not yet been computed; but I should estimate that the mean temperature at night was about 32°, and in the day about 55°."

It is a remarkable and interesting fact that the insect fauna of snow-fields consists almost entirely of species which are either black or very dark colored, although closely related species living amid different surroundings may be brightly decorated. That this is true in certain cases, as of the snow-inhabiting Campodeæ of the Alps, *Deesoria glacialis* and *Degeeria nivalis*, is well known to zoölogists, but the all but universality of the fact is not fully appreciated, except among entomologists who have studied Alpine and boreal forms. As long ago as 1834 Fröbel and Heer pointed out the existence of this relation between the pigmentation of insects and a snowy environment. They have compiled ('34, II, 97) tables showing the increase of dark pigments among the representatives of many species and genera of Coleoptera, Lepidoptera, Diptera, Arachnida, etc., as they extend to and beyond the snow line on the Alps or toward the north on the European continent.

A related fact is that insects which mature and become active during the winter in this latitude are likely to be black, or at least dark colored, although closely related species which are active at other seasons are much paler or brighter. This may be abundantly verified in the minute Diptera and Campodea which frequent sunny spots on the snows of late winter and early spring in the neighborhood of Philadelphia, or by reference to a paper by Fitch ('51), on the winter insects of New York, in which about twenty species of Campodea, Neuroptera and Diptera are described, every one of which is wholly or chiefly some shade of black. Associated with the " snow-worm " on the Malaspina Glacier was found a small Podurian, *Achorutes nivicola*, also black; and in the neighborhood of the glacier were collected a number of moths, flies and spiders, which have been described respectively by Skinner, Johnson ('98) and Banks ('98). So far as the colors of these have been noted, they are confirmatory of the general fact stated above.

It seems probable that the same causes which have stimulated the formation of pigment in the Oligochæta also favor its production in the Tracheata, and that some factor in a snowy environment lays the brand of melanism upon all of the constituents of its invertebrate fauna. But an analysis of the physical and vital conditions makes it evident that any one or several of five or six factors may be the effective cause, and until some of these can be eliminated by the conditions of experimentation it is almost idle to speculate. Apparently the most important physiological result to the organism of such a coat of pigment would be to place it in closer thermic relations to its surrounding. By virtue of it the organism could absorb a greater amount of radiant energy from an external source of greater intensity, but it would also lose its internal heat more rapidly to a cooler medium with which it was in contact. This being the case, it seems impossible to apply Lord Walsingham's ('85) hypothesis, valuable though it may be when applied to insects alone, to our worm. Lord Walsingham calls attention to the very striking fact that while many warm-blooded animals become white when subjected to Arctic conditions, the very opposite takes place in insects. He points out that it is vitally necessary for a homothermic animal to retain as much as possible of its internal heat during cold weather. A white coat favors this. An insect, on the contrary, having a variable temperature, becomes dormant whenever the external temperature falls below the minimum for its metabolic activity, but becomes more and more active with increasing temperature. In Arctic climates the season of activity for insects is very short. It is manifestly advantageous, therefore, that during it, metabolism be as rapid as possible. Increased capacity to absorb radiant energy would therefore be beneficial.

Inasmuch as the snow-worm does not, according to Mr. Bryant's account, expose itself to the sun's rays, it cannot benefit by its capacity to absorb heat rays, except possibly during the short period when it lives in the glacier pools. Even if they were to come to the surface of the snow while the sun shone, it seems to me that they could gain no appreciable amount of heat. The heat absorbed would be immediately transferred to the surrounding snow, which would melt, and the worm would simply tend to sink beneath the surface. This would be the only change resulting from its capacity to absorb heat rays. Zoölogical literature fairly bristles with attempted explanations of melanism. Some are simply attempts to correlate melanism with certain factors of the physical environment; others are more or less ambitious essays to explain the general fact or special cases. Without seeking to exhaust the field, I have applied more than a dozen of them to the case of this worm, without finding one that fits all of the conditions.

The Oligochæta are generally associated with warm, moist situations. We meet with them mostly during the spring and early summer months, while during the winter they retire from sight by burrowing into the earth below the frost line. Yet every one knows that after a warm rain in winter vast numbers of our common genera are often left dead on the surface of the ground to become the food of fowls, crows and other birds. A few warm days will start earth-worms into conspicuous activity, and many species retire beneath the surface only just so far as the actual freezing of the soil compels them. Our common Enchytræidæ are often found in clods of earth which are more or less completely frozen, or in the interior of frozen logs amid crystals of ice. This capacity of Oligochæta, and especially of the Enchytræidæ, to resist cold is now well known. Zoölogical literature contains the following cases: Leidy ('84) describes some small worms (which he refers to *Lumbriculus*, but later ('85) describes as *Lumbricus glacialis*, which is an Enchytræid) found frozen in a block of ice taken from a mill-pond in Delaware County, Pa. With them were associated *Rotifer vulgaris* and some immature Anguillulæ. Later some similar worms were received in a block of ice harvested from a pond near Moorestown, N. J., nearly a year before. This ice was filled with air bubbles and water drops in which the worms could be seen. On the ice being melted, the worms were liberated in an active condition and moved about in the water, but died as the latter became warmed. Dr. Leidy supposed that they were not actually frozen while imprisoned in the ice. He describes them under the name of *Lumbricus glacialis* ('85).

Kraus ('86) states that a small white worm was abundant in the ice supplied to the town of Salina, Kans., during the summer of 1885. As the ice melted they became somewhat active, but died when the temperature of the water reached 60° F. The same species was found living in the mud at the bottom of stagnant pools. Its presence in the ice is accounted for by the water having frozen to the bottom in the ponds from which the ice had been taken.

Reecker ('96) found a living earthworm in natural ice on July 16. It was moving about in a cleft in the centre of a piece of ice. The cleft communicated by a minute opening with the exterior. He supposed that in February or March, during a thaw, the worm had crawled between two blocks of ice which subsequently were frozen together. This worm, which was identified as *Lumbricus rubellus*, remained alive in the water until killed for preservation.

Sekera ('96) observed specimens of earthworms of the species *Dendrobœna rubida* Nj. (=*Allolobophora boeckii* Eisen) frozen in blocks of ice in East Bohemia in December, 1886. When freed from the ice they remained alive in the water for a week, when they were preserved. This species is abundant in bottom lands and along meadow brooks, and Sekera suggests that the worms crawled out on the surface of the snow on a sunshiny winter's day, and were imprisoned by the formation of an icy crust after nightfall.

Probably most naturalists have met with similar cases illustrating the cold-resisting power of earthworms. I add the following: While at Woods Holl, Mass., in the summer of 1893, Mr. Joseph Fay submitted to me for examination a large number of Enchytræids taken from ice which had been cut during the previous winter on his pond. Subsequently I received some of the ice containing the living worms. This ice was porous and filled with air or marsh gas vesicles like that sent to Dr. Leidy from New Jersey. The worms became active in the ice water, but died during the course of two days, the temperature of the water having risen to that of the air. This worm is probably identical with the *Lumbricus glacialis* of Leidy, and the "Lumbricoid" described by Kraus ('86). It belongs to the genus *Enchytræus,* but the species is not stated in my notes, and the specimens are not just now available for examination.

During the fall and winter of 1892-3, I kept a large number of living annelids in my bedroom. Among these was an undetermined species of *Limnodrilus,* about thirty specimens of which lived in a tumbler of water. During some of the coldest nights of the winter, when the temperature outside descended nearly to zero, this tumbler remained standing on the sill of a window which was opened for ventilation. In the morning the contents would be a solid lump of ice with a tangled mass of the worms embedded in its centre. During the day the ice would thaw and by evening the worms would be actively waving their posterior ends. This alternate freezing and thawing was repeated many times and on one occasion the tumbler was placed in the open air and its contents kept frozen for a week At the close of the winter all of the worms except three or four were still alive and normal.

I know of no careful experiments on Oligochæta to determine the minimum temperatures which can be resisted without loss of life, but Rœdel ('86) has recorded some experiments which he made on fresh-water leeches. *Aulastomum gulo* resisted a temperature of 2° C. for twelve to fifteen hours, and *Clepsine complanata* a temperature of 5° C. for ninety minutes. The question whether organisms can be actually frozen without consequent disorganization and death has often been raised. It would seem that such small, soft-bodied animals as leeches and Oligochæta must inevitably be frozen when subjected to the conditions described above, and yet they were uninjured, but the experimental proof of this is inconclusive. It is significant, however, that animals with thick, non-conducting external coats, as insects, centipedes and snails (Rœdel, '86, and Pictet, '93) resist much lower temperatures and for a longer time than soft-bodied animals. There is little doubt that the protoplasm of vertebrate tissues will withstand actual freezing and recover its activity upon being thawed. Landois and Stirling ('91) state that frogs will recover after the blood has been frozen and ice has formed in the peritoneal cavity; and among Pictet's remarkable experiments it is recorded that the ciliated epithelium of the frog's mouth was subjected to the extremely low temperature of —90° C. for an entire day and night and yet the cilia recovered their activity when the temperature had been gradually raised above 0° C.

The internal temperature of most of the lower invertebrates rises generally less than a degree above the surrounding temperature (Landois and Stirling, '91, p. 427). Metabolic activities diminish with the lowering of the temperature and, in the animals (vertebrates) which have been most studied, practically cease altogether at the freezing point of water.

Now this snow-worm lives and grows while maintaining a bodily temperature which can seldom vary much from the freezing point of water. According to Mr. Bryant, it lives during the summer in the melting snow and the water derived therefrom which collects in hollows and clefts on the ice. During the night, the period of its activity, when it comes to the surface of the snow, the mean temperature of the air is about 32° Fahr. When the sun shines the worms descend into the melting snow—a veritable freezing medium, which must keep their small bodies continually chilled to its own temperature. An intimate temperature relation between the worm and its surroundings is further enhanced by its pigmented surface which favors both radiation and absorption of heat. In being thus adapted to a bodily temperature very near to that of the minimum for protoplasmic activity, this worm resembles deep-sea animals. Semper has shown ('81) that it is the mean temperature, and not its fluctuations, which is important in determining the rate of growth of an animal; and here we have an organism whose optimum temperature has probably been adjusted to a point at which metabolism ceases in most other animals. Nothing is known of the winter habits of the worm, but no doubt it burrows deeply into the snow, and thus protected, lives in an environment the temperature of which probably varies little from that of its summer habitat at the surface.

But little is known as yet of the geographical distribution of the Enchytræidæ. They have been described from Europe, Asia, North and South America, Greenland and New Zealand. But it is only in Europe that our knowledge of the species and their distribution is even approximately complete. From what is known of the distribution of the Eurasian species the statement seems to be warranted that this family reaches its greatest development in the colder regions. Species abound in Siberia, Nova Zembla, Denmark and Norway, and some are found in Spitzbergen and Greenland, where other Oligochæta are very rare. Very few species have as yet been described from the American continent, but, so far as our information goes, it confirms the results of a study of the distribution of the Old World forms. The tropical and subtropical forms appear to be few and small, while many have been described by Michaelsen ('88^b) and Ude ('96) from the southern extremity of South America. They abound and present much variety in the northern United States, though but comparatively few species have been described. What is stated for the family seems to be preëminently true of the genus *Mesenchytrœus*. Of the eleven species recorded for Eurasia, none have been reported south of Germany, where Michaelsen ('89) has found and described three species; three species are also found each in Siberia (Eisen, '79), Nova Zembla (Eisen, '79, and Levinsen, '83) and Denmark (Levinsen, '83). None have been reported from North America, but two species, one of which is probably *M. beaumeri* Mich., and the other undescribed, occur in the neighborhood of Philadelphia. Ude mentions no *Mesenchytræus* from South America in his recent exhaustive paper ('96). It is perhaps not so surprising that a member of this seemingly almost Arctic genus should be found amid the snow and ice of a northern glacier. Most of the Arctic species collected by Nordenskjold and described by Eisen were found in moss or under stones. The only mention[3] which I find in the literature of a similar habitat of an Oligochæte is the following brief passage in Nordenskjold's *Grönland* ('86, p. 193): "With the exception of a few birds (seen) on the return trip the only animal observed was a worm living on the different species of ice algæ and therefore probably belonging to the fauna of the inland ice." This worm has not been described, and if really an Oligochæte, may be identical with *Mesenchytræus solifugus.*

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[3] The "snow-worms" have been reported by previous explorers of the glaciers of Alaska; by Prof. Wright ('87), from the Muir Glacier, and Prof. Russell, from the Malaspina Glacier. Prof. Wright has kindly sent me some examples collected by him from shallow pools of water on the ice sheet. They prove to represent both *M. solifugus* and *M. nivus.* Prof. Russell ('92) fully confirms Mr. Bryant's account of their habits in the following passage: "In the early morning before the sunlight touched the snow its surface was literally covered with small, slim, black worms, about an inch long, ... These creatures were wriggling on the snow in thousands, but as the sun rose and made its warmth felt they disappeared beneath the surface. They are not seen when the temperature is above freezing." In a letter Prof. Russell adds the interesting information that he has observed similar worms on the snows of Mt. Rainier, Wash., thus indicating for them a wide distribution. Arctic and Alpine explorers should be on the watch for them.

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EXPLANATION OF PLATE VII.

MESENCHYTRÆUS SOLIFUGUS.

Fig. 1. A ventral view of the anterior twelve somites of the worm, showing the position of the spermathecal and male and female genital pores. × 20. st, spermathecal pore at IV–V. ♂ male, ♀ female, pores.

Fig. 2. Profile view of the anterior thirteen somites of the same specimen, showing the position of the setæ bundles. Lettering as before. The lips of the atrium are everted to form a penis. × 20.

Fig. 3. Semidiagrammatic figure of the reproductive organs contained in somites XI–XXII. × about 35. *t*, testes; *ss*, left sperm sac; *rss*, right rudimentary sperm sac; *sf*, sperm funnel; *vd*, sperm ducts (the right one, lying within the ovisac, is here represented diagrammatically as nearly straight; the left, lying in the cœlom, is exhibited with nearly its actual arrangement of folds and coils); *se*, saccus ejaculatorius; *a*, atrium; ♂, male pore, here shown in a position much more laterad than is proper; *ov*, ovaries; *ovs*, the single ovisac, here represented as only partly filled with ova; ♀, female pore in a position more laterad than is natural.

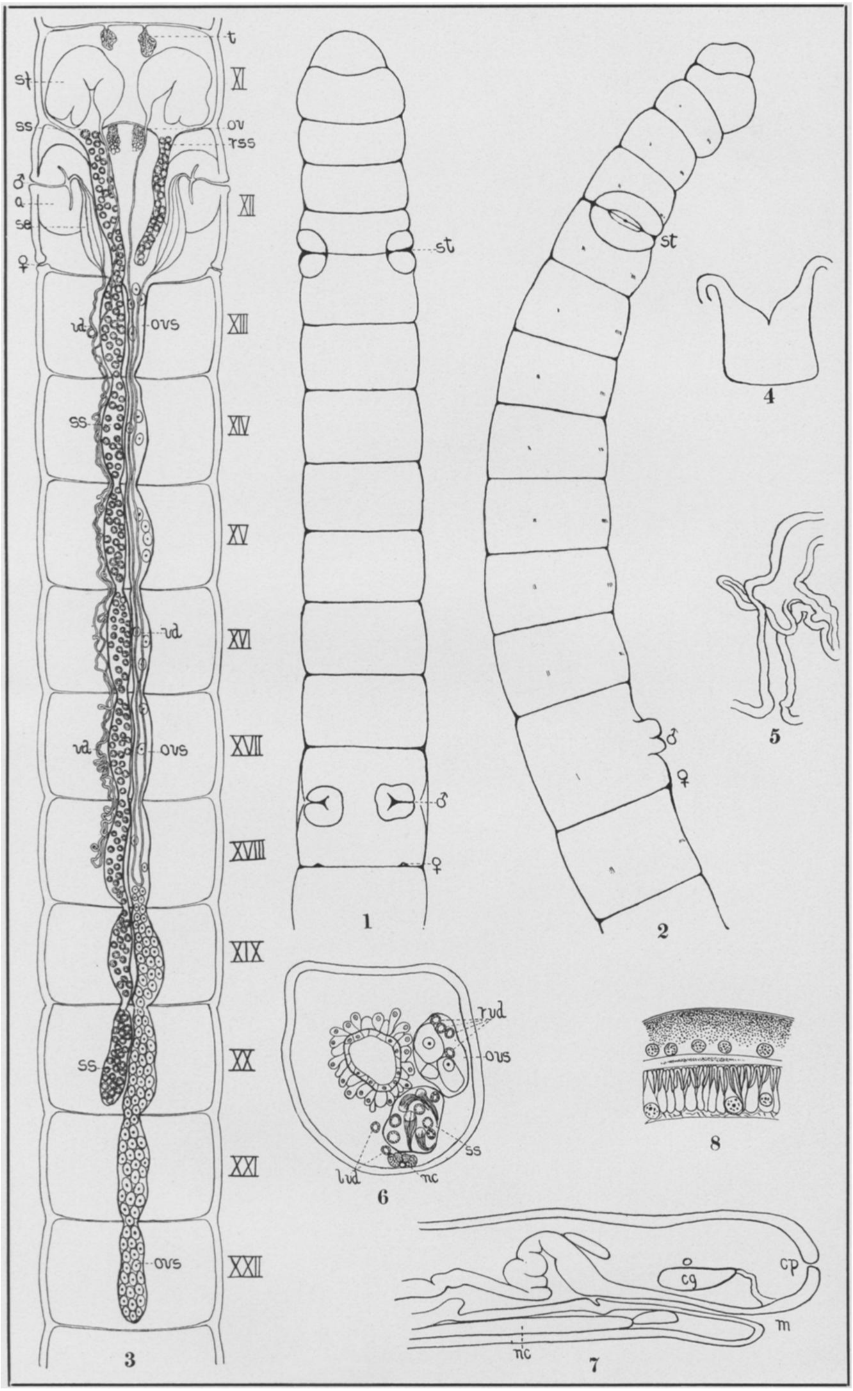
Fig. 4. Outline of the supracœsophageal gland, from a dissection. × 48.

Fig. 5. Outline and optical section of a spermatheca showing the three diverticula and the external pore below; the upper end is broken and the ampulla not so large as usual. The point where the break is indicated is about where it becomes continuous with its fellow and opens into the œsophagus. × 48.

Fig. 6. A section through somite XVI, showing the relation of the sperm sac, ovisac and the sperm ducts to one another and the intestine and nerve cord. × 55. *ss*, sperm sac filled with developing spermatozoa; *ovs*. ovisac containing ova and the right sperm duct; *lvd*, left sperm sac; *nc*, nerve cord.

Fig. 7. Median vertical section through the anterior end. × 55. *m*, mouth; *cp*, cephalic pore; *cg*, supracœsophageal ganglion; *nc*, ventral nerve cord; *ph*, pharyngeal pad.

Fig. 8. Section of a small portion of the body wall, from the preclitellar region, showing the remarkable development of pigment granules in the epidermis. × 440.



MESENCHYTRAEUS SOLIFUGUS. (EMERY.)